343-D

Model W and WM

BECKMAN

Instruments

INSTRUCTION MANUAL

Model W
Industrial pH Meter

•

Model WM
Industrial Millivolt Indicator

REVISION SHEET

Model W Industrial pH Meter **343**

Model WM Industrial Millivolt Indicator

NOTE

If the Model W is NOT used to operate a recorder, connect a shorting wire between Terminal 2 and Terminal 5 instead of the Recorder Resistor, R26.

The special RECORDER RESISTOR (supplied) MUST be connected across the left sides of Terminals 2 and 5 IF the Model W is used to operate a recorder. See RECORDER REQUIREMENTS.

Installation of a new Preamplifier in the Model W (or Model WM) Industrial pH Meter may make it necessary to readjust the Coarse Zero Control (R24). This Control (a wirewound resistor) is located on the printed circuit board. See illustration of amplifier chassis with covers removed in Instruction Manual 343.

Check the Coarse Zero Adjustment as follows:

1. Lock down the Zero-Check Pushbutton.
2. Rotate the Zero Control to move the meter needle to mid-scale.
3. If the meter needle DOES NOT move to mid-scale, rotate the Zero Control to the approximate center of its travel and adjust the slider on R24 to move the meter needle as close to mid-scale as possible.
4. Rotate the Zero Control until the meter needle DOES read mid-scale.

NOTE

If adjustment of the Coarse Zero Control FAILS to move the meter needle to within the range of the Zero Control, check possible causes of trouble as instructed in the Maintenance Section of Instruction Manual 343.

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IMPORTANT

The Preamplifier Assembly has been packaged separately to prevent breakage during shipment. Install this unit before connecting the Model W or Model WM to the power line.

1. Remove "filler" from amplifier chassis.

2. Plug Preamplifier into Printed Circuit Board; fasten with battery nut.

3. Carefully connect taper pin lead to spring clip on bottom of Preamplifier. See Figure 6.

TABLE OF CONTENTS

Page

SECTION I—MODEL W OPERATION 1

A. Description 1
B. Specifications 1
C. Recorder Requirements 2
D. Installation 2
E. Terminal Connections 2
1. Ground Connections 2
2. Recorders 3
3. External Meters 3
4. Electrodes 3
5. Power 3

F. Operating Controls 4

1. ZERO CHECK Push Button 4
2. ZERO LOCK Push Button 4
3. ZERO Control 4
4. STANDARDIZE Control 4
5. Meter Zeroing Control 4

G. Stepwise Operation . . . . .

1. Preliminary Steps 4
2. Grab Sample Standardization 4
a. Without Auxiliary pH Meter 4
b. With Auxiliary pH Meter 5

3. Direct Standardization in Buffer 5

SECTION II—MODEL W MAINTENANCE 6

A. Symptoms and Remedies 6
1. Amplifier Check 6
2. Electrode Circuit Check 7

B. Removal of Units 8

1. Chassis Cover 8
2. Input Circuit Cover 8
3. Preamplifier 8
4. Printed Circuit Board 8
5. Power Supply 10

C. Trouble-Shooting Tests 10

1. Amplifier-External Circuitry 10
2. Grid Current—Insulation Leakage 10

D. Circuit Operation 11

1. Working Amplifier 15
2. Power Supply 15

E. Circuit, Solution Grounds 15

SECTION III—MODEL WM OPERATION 17

A. Description 17
B. Specifications 17
C. Recorder Requirements 18
D. Installation 18
E. Terminal Connections 18
F. Operating Controls 18
1. On-Scale Zero Range 18
a. ZERO CHECK Push Button 18
b. ZERO LOCK Push Button 18
c. ZERO Control 18
d. Meter Zeroing Control 19
2. Off-Scale Zero Ranges 19
a. SET A Control 19
b. SET B Control 19
c. SET A Push Button 19
d. SET B Push Button 19
e. Meter Zeroing Control 19
G. Stepwise Operation 19
1. On-Scale Zero Range 19
2. Off-Scale Zero Ranges 19

SECTION IV—MODEL WM MAINTENANCE 20

A. Circuit Operation 20

APPENDIX I—RECORDER MODIFICATION 24

MODEL W PARTS LIST 25

MODEL WM PARTS LIST 26

LIST OF ILLUSTRATIONS

Page

Figure 1. Model W Industrial pH Meter 1

Figure 2. Mounting Dimensions 2

Figure 3. Model W Terminal Connections 3

Figure 4. Basic Circuit Diagram 6

Figure 5. Amplifier Chassis and Rear Panel 8

Figure 6. Amplifier Chassis With Covers Removed 9

Figure 7. Amplifier Test Circuit 10

Figure 8. Complete Schematic Wiring Diagram 12

Figure 9. Pictorial Wiring Diagram 13

Figure 10. Typical Circuit and Solution Ground Connections 14

Figure 11. Model WM Industrial Millivolt Indicator 17

Figure 12. Model WM Terminal Connections 18

Figure 13. Basic Circuit Diagram, −500 to +500 MV Range 20

Figure 14. Pictorial Wiring Diagram, −500 to +500 MV Range 21

Figure 15. Basic Circuit Diagram, 300 to 900 and 700 to 1400 MV Ranges . 21

Figure 16. Pictorial Wiring Diagram, 300 to 900 and 700 to 1400 MV Ranges 22

Figure 17. Complete Schematic Wiring Diagram, Three Model WM Ranges . 23

CONDENSED OPERATING PROCEDURE

(Grab Sample Standardization)

1. Lock ZERO CHECK Push Button down and allow 30 minutes for "warm-up."
2. Withdraw portion of sample and determine its present pH, using auxiliary pH meter, electrodes, and buffer.
3. With the ZERO Control, set meter needle or recorder pen to mid-scale.
4. Unlock the ZERO CHECK Push Button.
5. Rotate STANDARDIZE Control to set meter needle or recorder pen to exact pH value of grab sample.

ALTERNATE CONDENSED OPERATING PROCEDURE

(Direct Standardization in Buffer)

1. Lock ZERO CHECK Push Button down and allow 30 minutes for "warm-up."
2. Immerse electrodes and thermo-compensator in buffer.
3. With the ZERO Control, set meter needle or recorder pen to mid-scale.
4. Unlock ZERO CHECK Push Button.
5. Rotate STANDARDIZE Control to set meter needle or recorder pen to exact pH value of the buffer.
6. Lock ZERO CHECK Push Button down.
7. Immerse electrodes and thermo-compensator in sample.
8. Unlock ZERO CHECK Push Button.
9. Read pH value from meter or recorder scale.

Section I

MODEL W OPERATION

Figure 1. Model W Industrial pH Meter

A. DESCRIPTION

The Model W Industrial pH Meter is a dc-amplifier designed specifically for measuring potentials generated by pH-sensitive electrodes. The output signal is suitable for operation of most available recorders, controllers, recorder-controllers, and/or external indicating meters. This instrument also can be used with special Beckman electrode switches to monitor several sets of pH electrodes. The Model W is available in three standard pH ranges: 2 to 12 pH, −1 to 9 pH, and 4 to 14 pH.

The Model W features printed circuits and replaceable plug-in subassemblies to facilitate rapid field maintenance. The instrument case is gasketed to exclude moisture and dust. A bag of desiccant is supplied to be clipped to the rear panel (see Figure 5). Control knobs can be removed for "key" operation and tamper-proof installations. (Two keys are supplied.)

B. SPECIFICATIONS

1. ***Input Power:*** 50/60 cycle, 95-132 volts, 25 watts.

2. ***Ambient Temperature:*** −20° C to 50° C. See Bulletin 86 or Bulletin 342 for permissable ambient temperatures of pH electrodes.

3. ***Ambient Humidity:*** 100%.

4. ***Indicator:*** 204 (102-0-102) microamperes, 3½ in. scale divided into 10 pH units.

5. ***Warm-Up Time:*** 30 minutes.

6. ***Maximum Drift:*** 0.08 pH/day (5 mv/day). Initial drift rate of 3 to 5 mv/hour reduces to 5 mv/day after 48 hours operation.

7. ***Ambient Temperature Change Effect on Zero:***

Maximum: .005 pH/degree C ambient change.

8. *Accuracy:* Recorder output 0.02 pH units. Panel meter 0.1 pH units. Reproducibility of panel meter is 0.02 pH units.

9. *Response:* Amplifier response 2.0 seconds (may be further limited by electrode response).

10. *Output Signals* (for full span of 10 pH units):
a. Recorder or Controller
10 to 500 millivolts (potentiometric type)
204 microamperes (current type)
Recorders should have mid-scale zero or provision for setting zero to mid-scale.
b. External Meter
102-0-102 microamperes

11. *Input Detector Elements:*
a. Standard Beckman Glass Electrode
b. Standard Beckman Reference Electrode
c. Beckman Thermo-compensator

NOTE: *Consult a Beckman Sales Engineer for advice in selection of electrodes for specific applications. Beckman electrodes are described and illustrated in Bulletins 86 and 342.*

C. RECORDER REQUIREMENTS

The Model W may be used with most potentiometric or current type recorders having a mid-scale zero input point. Recorders having a left-scale zero input point must be modified for mid-scale zero input. See Appendix I for recorder modification data.

A special recorder resistor (R26) calibrated to supply the proper voltage to the recorder terminals must be connected across the left sides of terminals 2 and 5 on the Model W terminal strip. The following table gives the part number of the recorder resistor required for standard recorder sensitivities:

RECORDER SENSITIVITY	BECKMAN PART
10 mv	6956
35 mv	7394
50 mv	7395
70 mv	7396
100 mv	7097

Recorder resistors other than those listed may be obtained from the factory. Specify resistance required and the millivolt span recorder to be used. See Appendix I for instructions on computing the resistance of the recorder resistor required for any Model W installation.

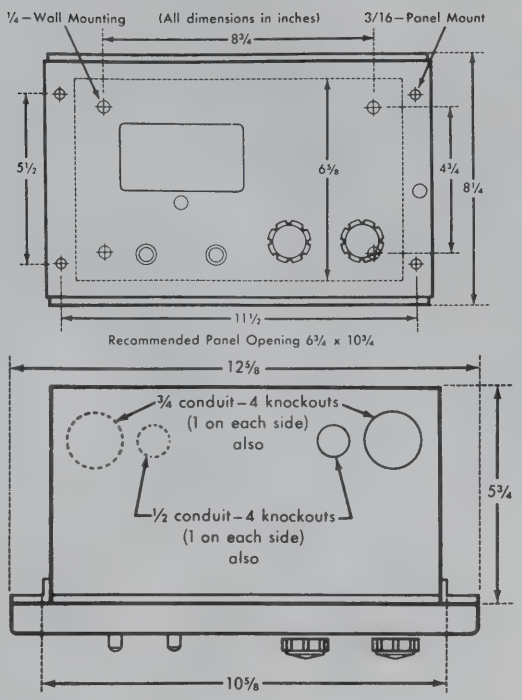


Figure 2. Mounting Dimensions

D. INSTALLATION

Wall and panel mounting dimensions for the Model W are shown in Figure 2. Run conduit into the instrument case through appropriate knockouts shown in the same illustration.

NOTE: *Join conduit to case in such a manner as to insure water-tight connections to the case. Seal all leads in the conduit at the point of entry into the case with the elastic rubber sealer supplied.*

NOTE: *Make sure that only fresh desiccant is used in the instrument. Replace desiccant at least every six months. Use only non-deliquescent drying agents.*

E. TERMINAL CONNECTIONS

All leads except those for the power line and the glass electrode connect directly to the terminal strip on the rear panel inside the Model W case. See Figure 3.

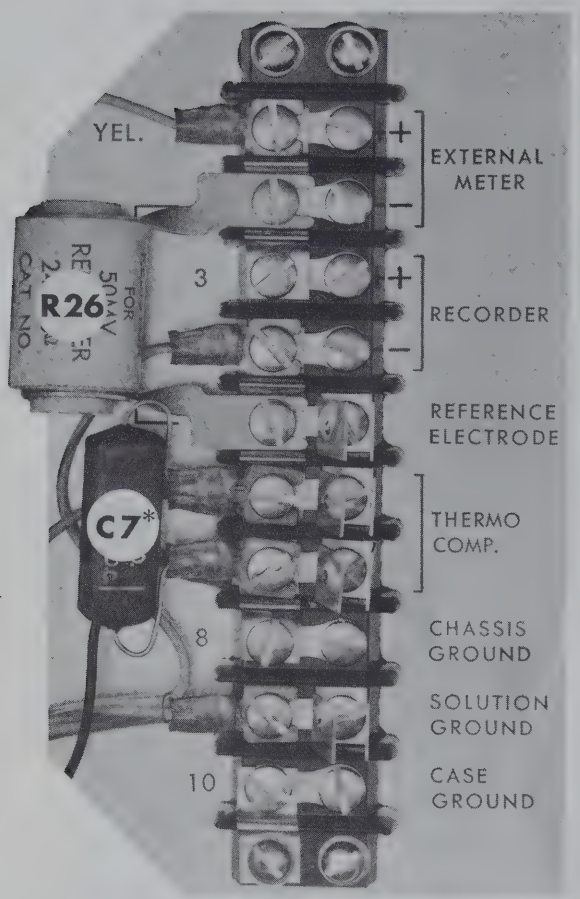
1. GROUND CONNECTIONS

a. Case Ground

Connect the CASE GROUND terminal (10) to a water pipe or similar earth ground.

b. Solution Ground

Connect the SOLUTION GROUND terminal (9) directly to the solution containing the electrodes, the solution tank, or the solution pipe.



*On some instruments, C7 will be mounted with C6 inside a common can on the rear panel.

Figure 3. Model W Terminal Connections

c. Chassis Ground

No additional connections necessary. See recorder connections, following.

2. RECORDERS

NOTE: *Leads to external indicating meter, recorders, or recorder-controllers must be well-insulated. Leads longer than 10 feet must be shielded, and the shield must be connected to the CHASSIS GROUND terminal of the Model W. The shield must be insulated to prevent contact with earth ground or other conductors. A two-conductor shielded cable (Beckman Part 1203) may be obtained from the factory. Specify length required.*

a. Potentiometric Type

Connect potentiometric recorder or recorder-controller leads to the RECORDER terminals (3 and 4), observing proper polarity.

NOTE: *The special recorder resistor (R26) must be connected across the left sides of terminals 2 and 5.*

b. Current Type

Connect current type recorder or recorder-controller leads to the EXTERNAL METER terminals (1 and 2). Cut or remove the short-circuit strap from across the left sides of terminals 1 and 2. See external meter connections, following.

3. EXTERNAL METERS

Connect external indicating meter leads to the EXTERNAL METER terminals (1 and 2), cutting or removing the short-circuit strap across the left sides of those terminals.

NOTE: *If an external indicating meter is used in conjunction with a current type recorder or recorder-controller, connect the meter IN SERIES with the recorder or recorder-controller. Two or more external units may be connected IN SERIES to the EXTERNAL METER terminals (1 and 2), provided that the total resistance of the units connected IN SERIES is less than 5,000 ohms.*

CAUTION: ***Replace the short-circuit strap across the left sides of terminals 1 and 2 if the external units are disconnected from the terminal strip.***

4. ELECTRODES

a. Thermo-compensator

Connect thermo-compensator leads to the THERMO-COMP terminals (6 and 7), without regard to polarity.

b. Reference Electrode

Connect the reference electrode lead to the REFERENCE ELECTRODE terminal (5).

c. Glass Electrode

NOTE: *The glass electrode connects directly to the amplifier, instead of the terminal strip.*

A metal jack is mounted on the chassis assembly (below the meter housing) to receive the glass electrode plug. The electrode plug presses against a spring contact and is held against the contact by a thumbscrew. (A 8480 Terminal Connector is available which will permit connection of a glass electrode lead with a spade lug tip.)

NOTE: *Some instruments also have a ceramic connector for the glass electrode lead, which accommodates a spade lug tipped lead. See Figure 6. Connect glass electrode shield to chassis screw below metal jack.*

5. POWER

Remove the center screw from the porcelain a-c power receptacle on the rear panel (see Figure 5) and connect the power cable leads to the terminals in the base of the receptacle.

F. OPERATING CONTROLS

1. ZERO CHECK PUSH BUTTON

The ZERO CHECK Push Button control is used in conjunction with the ZERO Control to zero the amplifier. Depressing the ZERO CHECK Push Button disconnects the electrodes from the amplifier, disconnects the STANDARDIZE Control, and connects the amplifier input lead to the REFERENCE ELECTRODE terminal.

2. ZERO LOCK PUSH BUTTON

The ZERO LOCK Push Button is used to lock the ZERO CHECK Push Button down. This keeps the electrodes disconnected from the amplifier while the electrodes are removed from solutions during standardization and maintenance.

To lock the ZERO CHECK Push Button down, press both push buttons simultaneously, then release the ZERO CHECK Push Button first.

To release the lock, press and release the ZERO CHECK Push Button.

3. ZERO CONTROL

This control compensates for amplifier drift. Its correct setting adjusts the input of the amplifier to ground potential, thus maintaining the voltage across the electrode cable insulation to within a few millivolts.

NOTE: *If the ZERO Control does not have sufficient range for proper operation, it will be necessary to adjust the Coarse Zero Control (R24)—an adjustable wirewound resistor located on the Printed Circuit Board. See Section II, A, 1, a.*

4. STANDARDIZE CONTROL

This control supplies a voltage to correct scale shift errors arising from electrode variations.

5. METER ZEROING CONTROL

This control is used to adjust the mechanical zero of the meter. Access to the control screw is through the hole just below the meter face.

NOTE: *Indicating meters on some instruments are mechanically zeroed by a lever adjustment. On these instruments, the adjustment lever extends down from the meter between the chassis and the panel-door.*

G. STEPWISE OPERATION

1. PRELIMINARY STEPS

a. Connect the instrument to the power line and allow 30 minutes for "warm-up."

b. Check the mechanical zero of the Model W indicating meter as follows:

(1) Lock the ZERO CHECK Push Button down.

(2) Disconnect one of the thermo-compensator leads at the Model W terminal strip.

(3) If the meter needle does not balance at mid-scale, remove the snapbutton plug from the panel hole just below the meter face, and adjust the meter needle with a screwdriver.

(4) Replace the snapbutton plug, and reconnect the thermo-compensator lead.

2. GRAB SAMPLE STANDARDIZATION

If the electrodes and thermo-compensator are installed in flow or immersion assemblies, grab sample standardization can be accomplished (a) without an auxiliary pH meter, or (b) with an auxiliary pH meter.

a. Without Auxiliary pH Meter

(1) Lock the ZERO CHECK Push Button down.

(2) Disconnect flow or immersion assembly electrode leads at the Model W terminal strip and amplifier.

(3) Connect auxiliary electrodes to the appropriate Model W terminals.

(4) Adjust the temperature of the buffer (of known pH) to the operating temperature of the process electrodes. Place the auxiliary electrodes, and a laboratory thermometer in the buffer solution.

(5) Allow one minute for the electrodes to reach equilibrium.

(6) With the ZERO Control, set the meter needle to mid-scale.

(7) Determine the pH of the buffer solution at this temperature. (Refer to the chart on the buffer package.)

(8) Unlock the ZERO CHECK Push Button.

(9) Rotate the STANDARDIZE Control to set the meter needle to the correct pH value of the buffer.

(10) Lock the ZERO CHECK Push Button down.

(11) Remove the auxiliary electrodes from the buffer, rinse these units in distilled water, and immerse them in a grab sample. (Maintain grab sample at operating temperature.)

(12) Unlock the ZERO CHECK Push Button.

(13) Read the correct pH of the grab sample.

(14) Lock the ZERO CHECK Push Button down.

(15) Disconnect the auxiliary electrodes from the Model W, and reconnect the flow or immersion assembly electrodes to their respective terminals.

(16) Rotate the STANDARDIZE Control to set the indicating meter to the correct pH of the grab sample.

NOTE: *The meter needle may drift for several minutes after the electrodes are reconnected (Step 15), indicating that the electrodes have been polarized. Wait until the meter reading stabilizes before making the final STANDARDIZE Control adjustment (Step 16).*

b. With Auxiliary pH Meter

(1) Use auxiliary electrodes with an auxiliary pH meter to standardize against the buffer.

(2) Remove the electrodes from the buffer, rinse them in distilled water, and immerse them in a grab sample.

(3) Read the pH of the grab sample on the auxiliary pH meter.

(4) Rotate the STANDARDIZE Control of the panel-mounted Model W to set that indicating meter to the correct pH of the grab sample (just determined on the auxiliary pH meter).

3. DIRECT STANDARDIZATION IN BUFFER

If the electrodes and thermo-compensator are installed in flow or immersion assemblies to which the operator has easy access, direct standardization in buffer is accomplished by using the flow or immersion assembly electrodes and thermo-compensator with the panel-mounted Model W.

a. Lock down the ZERO CHECK Push Button.

b. Remove the electrodes and thermo-compensator from the sample solution, and rinse these units in distilled water.

c. Adjust the temperature of the buffer (of known pH) to the operating temperature of the process electrodes. Immerse the electrodes and thermo-compensator in the buffer solution along with a laboratory thermometer.

d. Allow one minute for the electrodes to reach equilibrium.

e. With the ZERO Control, set the meter needle to mid-scale.

f. Compute the exact pH value of the buffer at this temperature. (Refer to the chart on the buffer package.)

g. Unlock the ZERO CHECK Push Button.

h. Rotate the STANDARDIZE Control to set the indicating meter to the correct pH of the buffer.

i. Lock down the ZERO CHECK Push Button.

j. Remove the electrodes and thermo-compensator from the buffer, rinse them in distilled water, and reinstall these units in the sample solution.

k. Unlock the ZERO CHECK Push Button.

l. The Model W meter will correctly indicate the pH of the industrial sample.

Section II

MODEL W MAINTENANCE

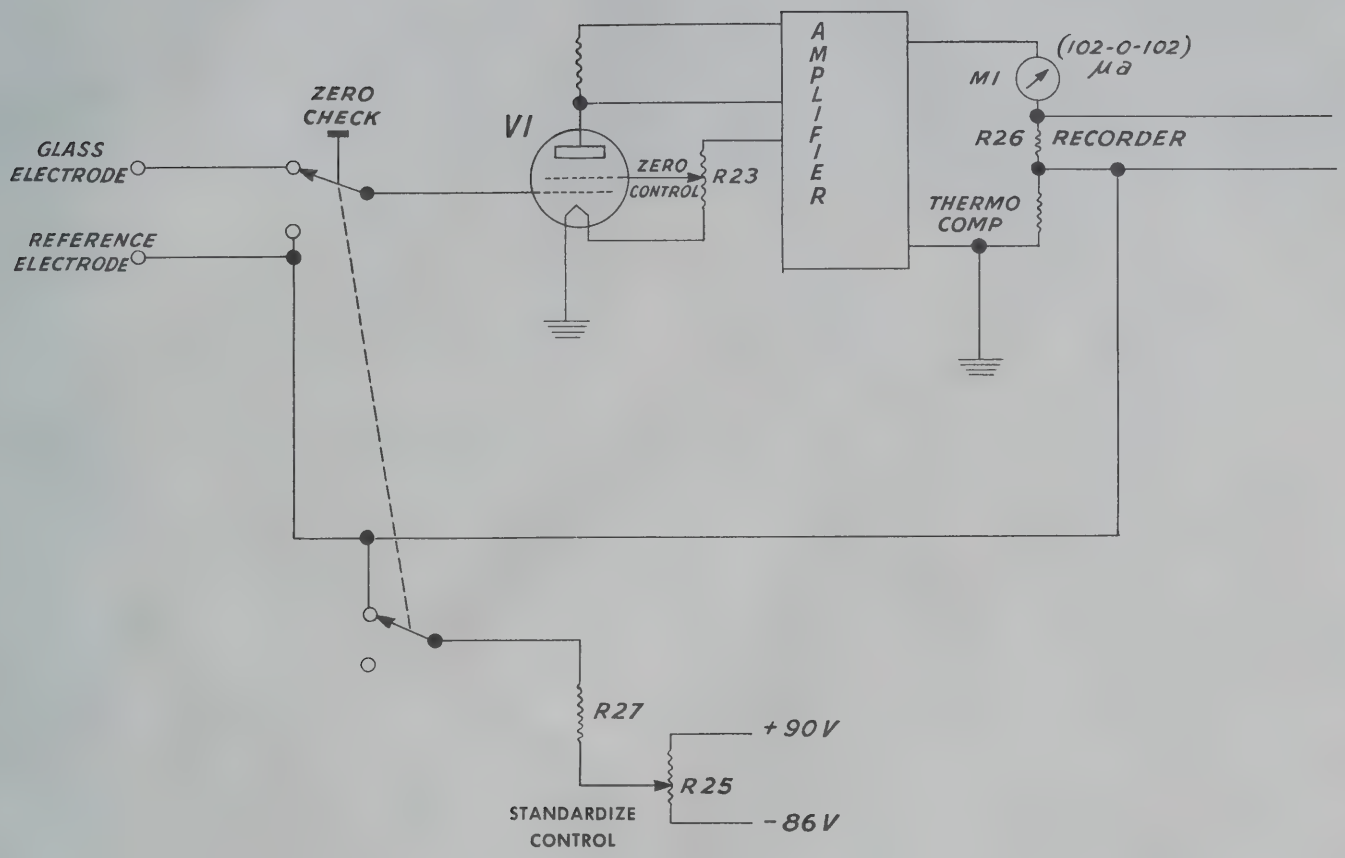


Figure 4. Basic Circuit Diagram

The symptoms and remedies described in Part A, following, enable quick diagnosis of most operating difficulties which may be encountered with the Model W Industrial pH Meter. Procedures for removing amplifier covers and plug-in units are listed in Part B. Additional trouble-shooting aids are included in Part C to help isolate either the amplifier or the external circuitry as the source of malfunction.

Basic circuit operation is explained in Part D, and circuit and solution ground tests are described in Part E.

A. SYMPTOMS AND REMEDIES

1. AMPLIFIER CHECK with ZERO CHECK Push Button depressed:

a. Meter needle stays at or near one end of the scale.

(1) Coarse Zero Control (R24) incorrectly adjusted.

Rotate ZERO Control to approximate center of its travel, then adjust slider on R24 (see Figure 6) to move the meter needle as close to mid-scale as possible. Rotate ZERO Control until meter needle DOES read mid-scale.

(2) Taper pin lead to Preamplifier is disconnected.

Connect lead. See Figure 6.

(3) Defective ZERO CHECK Push Button switch.

Bend switch leaf to which the taper pin lead is connected so that contact is made with the adjacent leaf.

(4) Defective regulated power supply.

Check voltage between chassis and the +90V point on the Printed Circuit Board, and between the chassis and the −86V point on the board. If the voltage at the −86V point is low or the voltage at the +90V point is high, check the resistance between Pins 8 and 5 on the Preamplifier unit. The resistance should be about 7500 ohms. If the circuit is open, filament(s) of sub-miniature tube(s) may be open. Replace Preamplifier unit.

(5) Defective Preamplifier or V4 Tube.

Connect a shorting strap between Pin 9 of the Preamplifier and Chassis GND on the Printed Circuit Board. Note movement of meter needle. Then, connect the strap betwen Pin 9 and the −86V point on the board. If the Preamplifier is defective, the meter needle will go off scale to the left in the first test, and to the right in the second test. Relace defective Preamplifier.

If the meter needle does not go off scale in each instance, a defective V4 Tube is indicated. Replace tube on Printed Circuit Board.

b. Rotation of ZERO Control causes meter needle to flip from one end of scale to the other, without coming to rest on scale.

(1) Input lead to Preamplifier is short-circuited to chassis at: thermo-compensator, recorder, or amplifier.

Disconnect thermo-compensator and/or recorder to isolate the trouble. Replace thermo-compensator, repair recorder, or repair defective insulation in either the reference electrode circuit or the Preamplifier input lead circuit.

c. Meter needle stays at mid-scale (or 7 pH on some early model instruments); voltage reference tube V5 glows.

(1) Thermo-compensator is defective (open-circuited) or connections to this unit are loose.

Tighten connections, or replace thermo-compensator.

(2) Recorder resistor (R26) connections loose, or resistor is defective (open-circuited).

Tighten connections, or replace R26 (see Figure 3). Make sure resistance of replacement R26 is correct.

d. Meter needle stays at mid-scale (or 7 pH on some early model instruments); voltage reference tube V5 DOES NOT glow.

(1) Dead power line.

Check power line connections.

(2) Defective fuse(s) F1 and/or F2.

Replace fuse(s). See Figure 6. If replacement fuse(s) blow, remove Printed Circuit Board and again replace fuse(s). If fuse(s) again blow, the Power Supply unit is defective; replace unit. If the second set of replacement fuse(s) does not blow, the Printed Circuit Board is defective; replace this unit.

(3) Defective voltage control tube V6.

Replace tube on Printed Circuit Board.

(4) Defective V5 tube.

Replace tube on Printed Circuit Board.

2. ELECTRODE CIRCUIT CHECK with electrodes installed and ZERO CHECK Push Button released:

a. Meter needle stays at one end of scale, or meter needle is unstable.

(1) One or both electrodes not immersed deep enough in solution.

Immerse electrodes at least two inches in solution.

(2) Poor "ground" circuit connection(s).

Check connection(s). See Section II, E.

(3) Defective glass electrode.

Replace electrode.

(4) Defective reference electrode.

Replace electrode.

(5) Poor insulation between chassis ground and earth (case) ground or solution ground.

Check chassis to ground insulation. See Section II, E. Also check recorder insulation.

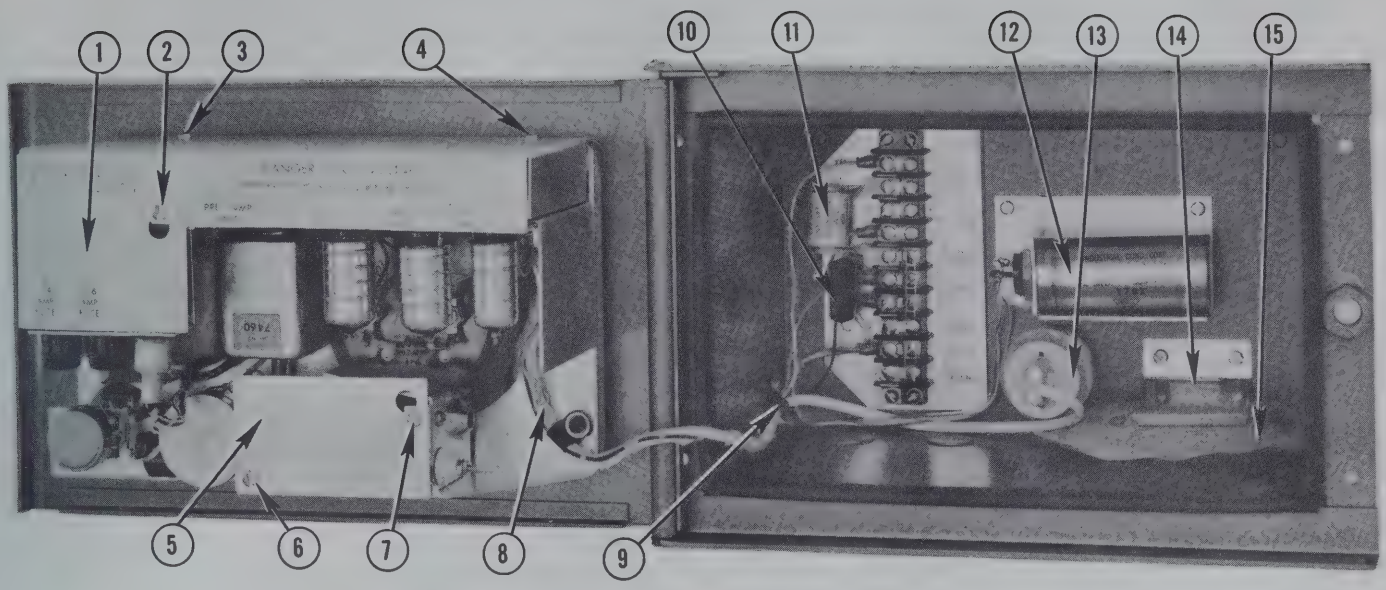
b. STANDARDIZE Control does not function.

(1) Thermo-compensator connections loose, or unit is defective.

Check connections, or replace thermo-compensator.

(2) Open input circuit.

Check input circuit connections: input switch, glass and reference electrode leads.



1. Chassis Cover
2–4. Chassis Cover Mounting Screws
5. Input Circuit Cover
6–7. Input Circuit Cover Screws
8. Power Cable
9. Power Cable Clip
10. Filter Capacitor C7*
11. Recorder Resistor R26
12. Filter Capacitor C6*
13. A-C Power Receptacle
14. Desiccant Clip
15. Desiccant Bag

*..*In some instruments, C6 and C7 are combined inside a common can of the rear panel.*

Figure 5. Amplifier Chassis and Rear Panel

(3) Open contact or shorts in input switch.

Check switch. Bend leaf of glass electrode contact spring to make contact with the leaf to which the taper pin lead is connected.

B. REMOVAL OF UNITS

For ease of maintenance, the Model W amplifier consists of three easily replaceable units: the Power Supply, a Printed Circuit Board, and a hermetically-sealed Preamplifier. Each of these units can be replaced separately in the field; the defective unit can then be repaired at a more convenient time.

1. CHASSIS COVER

See Figure 5.

Loosen screws 2, 3, and 4 to remove cover.

2. INPUT CIRCUIT COVER

See Figure 5.

Loosen screw 7 and swing the cover to one side, or remove screws 6 and 7 and remove cover entirely.

3. PREAMPLIFIER

See Figure 6.

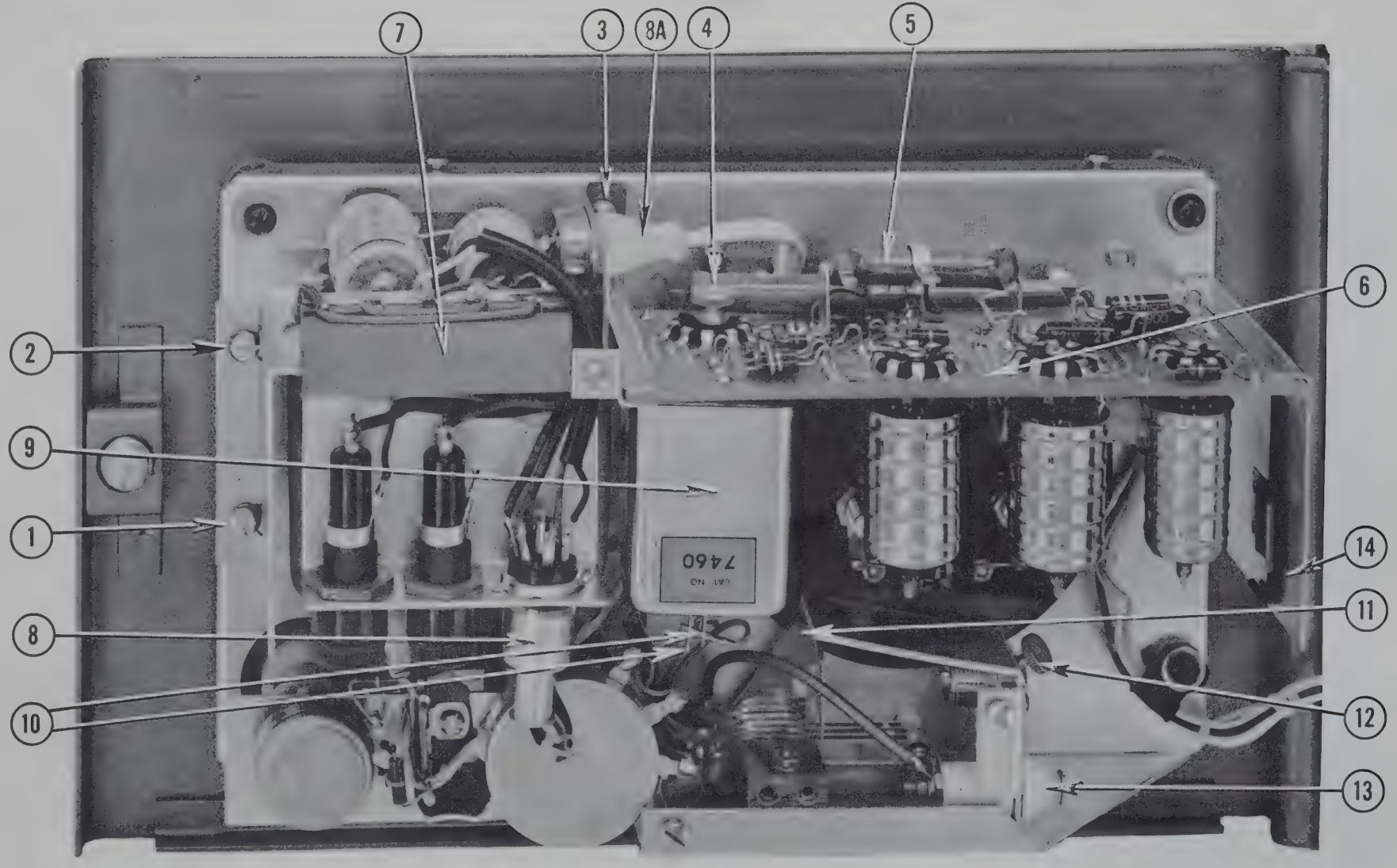
Remove the knurled battery nut (4), spring the left leg of the taper pin clip slightly to the left to disconnect the taper pin lead (10), and pull the unit from its socket on the Printed Circuit Board.

NOTE: *Before returning the instrument to operation, make sure that the taper pin lead, its receptacle on the Preamplifier, the input switch leaves, and the glass electrode contact spring do not come in contact with any other components or wires.*

4. PRINTED CIRCUIT BOARD

See Figure 6.

Remove the Preamplifier as previously instructed, or spring the left leg of the taper pin clip slightly to the left to disconnect the taper pin lead from the Preamplifier. Pull the board from its receptacle. (Insert a screwdriver through the hole in the board and use it as a lever against the meter housing. Be careful, however, not to pinch a wire with the tip of the screwdriver.)



1–3. Power Supply Mounting Screws
4. Battery Nut
5. Coarse Zero Control R24
6. Printed Circuit Board
7. Power Supply
8. Power Supply Output Plug
8A. Power Supply Input Plug
9. Preamplifier
10. Taper Pin Lead and Clip
11. Glass Electrode Input Spring
12. Glass Electrode Connector (Metal)
13. Glass Electrode Connector (Ceramic)
14. Allen Wrench

Figure 6. Amplifier Chassis With Covers Removed

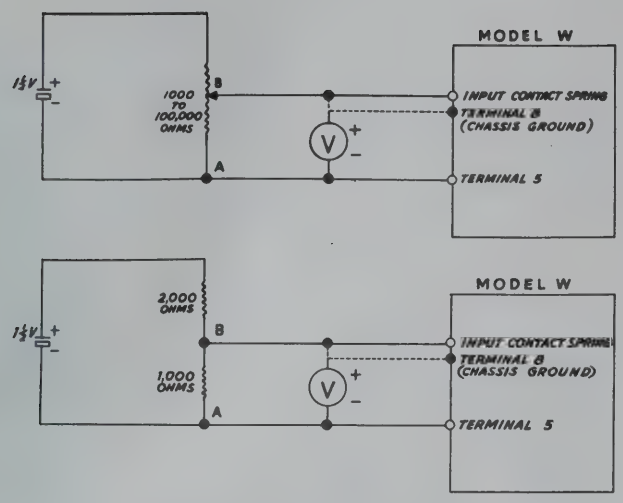


Figure 7. Amplifier Test Circuit

5. POWER SUPPLY

See Figure 6.

Disconnect the Power Supply output plug (8), disconnect the Power Supply input plug (8A), loosen screws 1, 2, and 3, and slide the Power Supply unit from the chassis.

NOTE: *The 7443 Power Supply unit used on instruments with serial numbers through 98662 does not have a SEPARATE Power Supply input plug (8A). The 4282 Power Supply unit (with SEPARATE input plug) replaces the 7443 unit on instruments with serial numbers 98663 and up, and is used as a replacement unit instead of the 7443 Power Supply.*

NOTE: *A 6815 Power Supply Adapter will be supplied with replacement 4282 Power Supply units ordered under the old catalog number 7443. Insert one end of the male adapter plug into the output plug of the replacement unit, and insert the other end of the male adapter plug into the female power plug used to connect the old-style unit. Run the adapter cable behind the Printed Circuit Board, and connect the female adapter plug to the male input plug on top of the replacement Power Supply unit.*

C. TROUBLE-SHOOTING TESTS

1. AMPLIFIER-EXTERNAL CIRCUITRY

The following steps are designed to help the operator isolate either the amplifier or the external circuitry as the source of trouble.

a. Apply a known voltage across the input connections to the Model W, using a voltmeter (one-volt range preferred), a 1½-volt battery, and either a potentiometer with a resistance of between 1,000 and 100,000 ohms, or two fixed resistors in series (1,000-ohms and 2,000-ohms), applying the potential from the 1,000-ohm resistor (about ½ volt). See Figure 7.

(1) Connect a lead from Point A on the potentiometer (or 1,000-ohm resistor) to Model W Terminal 5 and connect a lead from Point B to the input electrode contact spring (on the amplifier chassis).

(2) Connect the negative lead of the voltmeter to Terminal 5 and connect the positive lead to the input contact spring.

(3) Adjust the potentiometer to make the voltmeter read about ½ volt (500 millivolts).

(4) Move the positive lead from the voltmeter to Model W Terminal 8.

NOTE: *These polarities must be observed.*

The voltmeter should read exactly the same voltage as in Step (3). If the two readings agree, the amplifier is functioning properly. As a double check, repeat this test with all polarities reversed. Again, the two meter readings should agree.

(5) If the amplifier functions properly, the source of trouble is in the external circuitry. Starting with Terminal 8, check back through the electrodes to the input contact spring for open circuits, shorts, bad connections, etc.

(6) If the voltmeter readings do NOT agree, i.e., the amplifier is NOT functioning properly, a defective plug-in unit or output tube V4 may be indicated. Replace the three amplifier plug-in units (Preamplifier, Printed Circuit Board, and Power Supply) in order, until the defective unit is located.

2. GRID CURRENT—INSULATION LEAKAGE

The following steps are designed to help the operator isolate either grid current or insulation leakage as the source of trouble.

a. Connect a 510-ohm resistor across the right sides of terminals 6 and 7, in place of the thermo-compensator. This will change the instrument sensitivity to 100 millivolts for a full-scale span.

b. Connect a 20,000-megohm resistor (Beckman Part 8805) between the glass electrode contact spring and the REFERENCE ELECTRODE terminal (5), carefully shielding the resistor and its high impedance lead. (Connect the shield to the internal chassis.)

c. Connect a shorting strap across the resistor leads and record the meter reading.

d. Carefully remove the shorting strap from the glass electrode end of the resistor, wait for the meter needle to reach equilibrium, then again record the meter reading.

The difference between the second and first meter readings should be less than four pH units. This may be verified from the following relationships:

$$\text{MAX. ALLOWABLE } I_G = 2 \times 10^{-12} \text{ amps.}$$
$$\text{INPUT VOLTAGE} = I_G \times 20{,}000 \text{ meg.}$$
$$= 2 \times 10^{-12} \times 20 \times 10^{9}$$
$$= 40 \text{ mv}$$
$$\text{ON A SCALE OF: } 100 \text{ mv} = 10 \text{ pH}$$
$$40 \text{ mv} = 4 \text{ pH}$$

If the difference between readings is 4 pH or less, the grid current and insulation leakage current is 2×10^{-12} amperes or less; therefore this current is not the source of trouble.

Note that if the first reading is made near mid-scale, the input grid to chassis-ground potential must be approximately zero; the feedback action of the amplifier tends to keep this potential near zero while the second reading is taken.

However, if the ZERO Control is turned so that the first reading is near one end of the scale (choose the appropriate end so that the second reading will be on-scale), the grid to ground potential will be about 50 millivolts.

Grid current is independent of bias changes as small as this. Therefore, the difference between first and second readings, when taken near either end of the scale, should be the same as when taken near the center of the scale. In other words, the apparent current should be independent of the region of the scale in which the measurement is made.

This will not be true in actual practice, if a "leaky" insulator is present in the input grid circuit. In the instance where the first reading is at mid-scale, there will be no potential across such an insulator; therefore, no current will flow through it. This means that the first test for "grid current" will indicate only the actual current flowing into or out of the vacuum tube grid lead.

In the second instance, the same grid current will still flow, but, in addition, a second current will flow due to the potential across the leaky insulator. The second test for grid current will then indicate the actual grid current PLUS the leakage current. This is advantageous in that it provides a simple means of distinguishing between true grid current and insulation leakage currents.

It is recommended that the first check be made by starting at one end of the meter scale, thus checking the grid current and insulation leakage currents together. Then, if the difference between readings is greater than 4 pH, make a second check by starting at mid-scale (to read the grid current alone).

Excessive grid current will indicate a defective Preamplifier. Replace Preamplifier.

Excessive insulation leakage currents will indicate a defective glass electrode circuit. Disconnect the glass electrode from the Model W, electrode switch, and connector box. Reconnect these units, one at a time, to isolate the trouble.

D. CIRCUIT OPERATION

The working amplifier of the Model W pH Meter consists of two stages of voltage amplification and a power output stage. The amplifier circuit employs negative voltage feedback for stability.

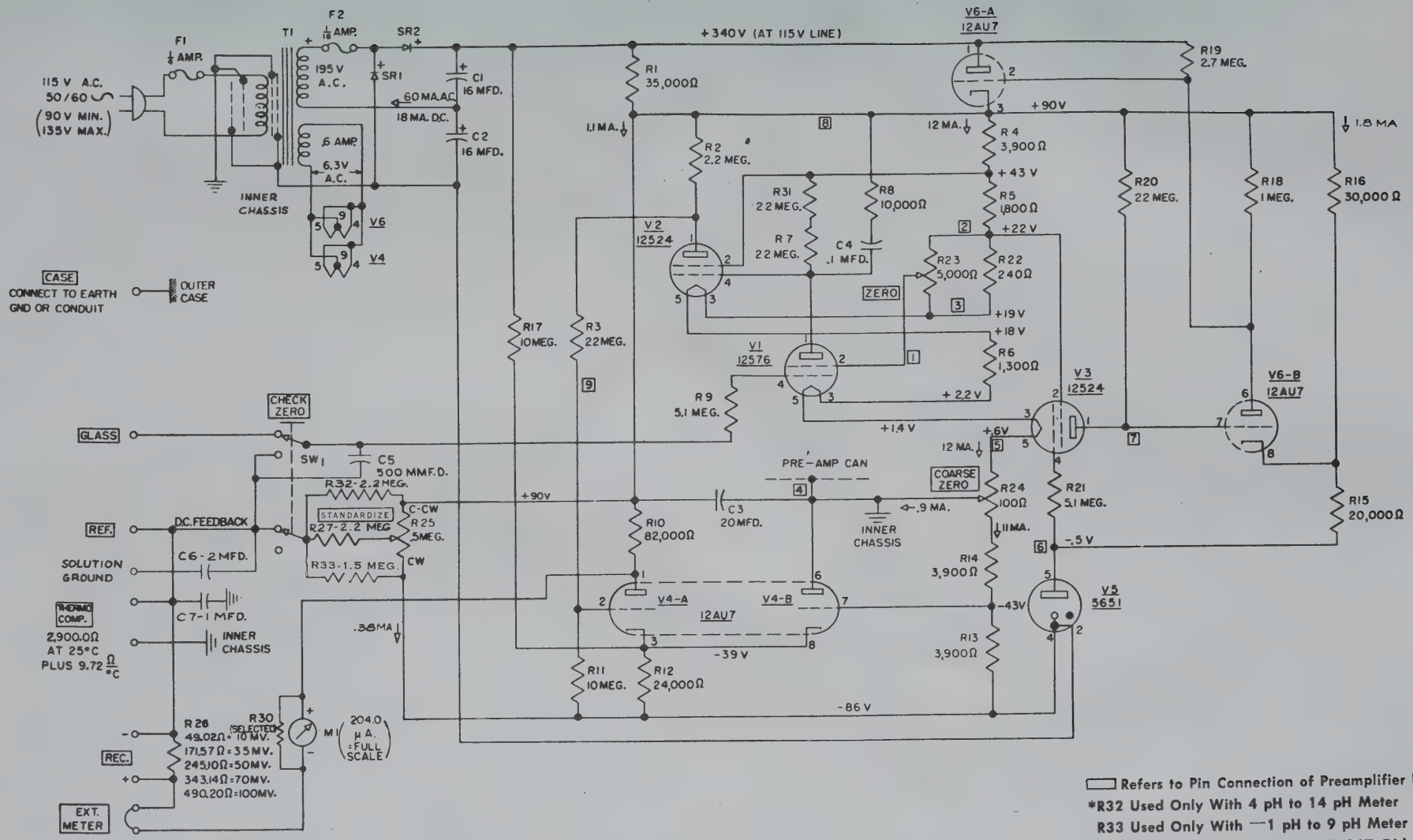
Figure 4 is basic circuit diagram which shows the relationship of the controls to circuit operation.

The instrument is essentially a voltmeter, i.e., the meter reading is proportional to a voltage (derived from pH electrodes) applied to the input terminals. By controlling the current through the thermo-compensator the amplifier produces a feed-back voltage across the thermo-compensator (feedback resistor) of the same magnitude as the signal voltage but of opposite polarity.

This feedback voltage is applied in series with the input signal in such a manner that the control grid of V1 is maintained at essentially constant potential with respect to ground, regardless of the size of the signal applied to the input terminals. (The actual grid to ground voltage is equal to the input signal divided by the amplifier gain—in this case Es/1,000.) The indicating meter monitors the thermo-compensator current.

When the ZERO CHECK Push Button is depressed, the input of the amplifier is connected to the REFERENCE ELECTRODE terminal and the ZERO Control is used to adjust the meter current to zero (mid-scale); this also means that no voltage exists across the thermo-compensator. When the ZERO CHECK Push Button is released and a signal is applied to the input, a voltage is developed across the thermo-compensator equal to the signal voltage.

The STANDARDIZE Control is used to make the meter read pH correctly—by compensating for the asymmetry potential of the electrodes. (The pH electrodes do not necessarily develop zero potential when immersed in a solution of 7 pH.) This asymmetry potential—a few



Refers to Pin Connection of Preamplifier Unit

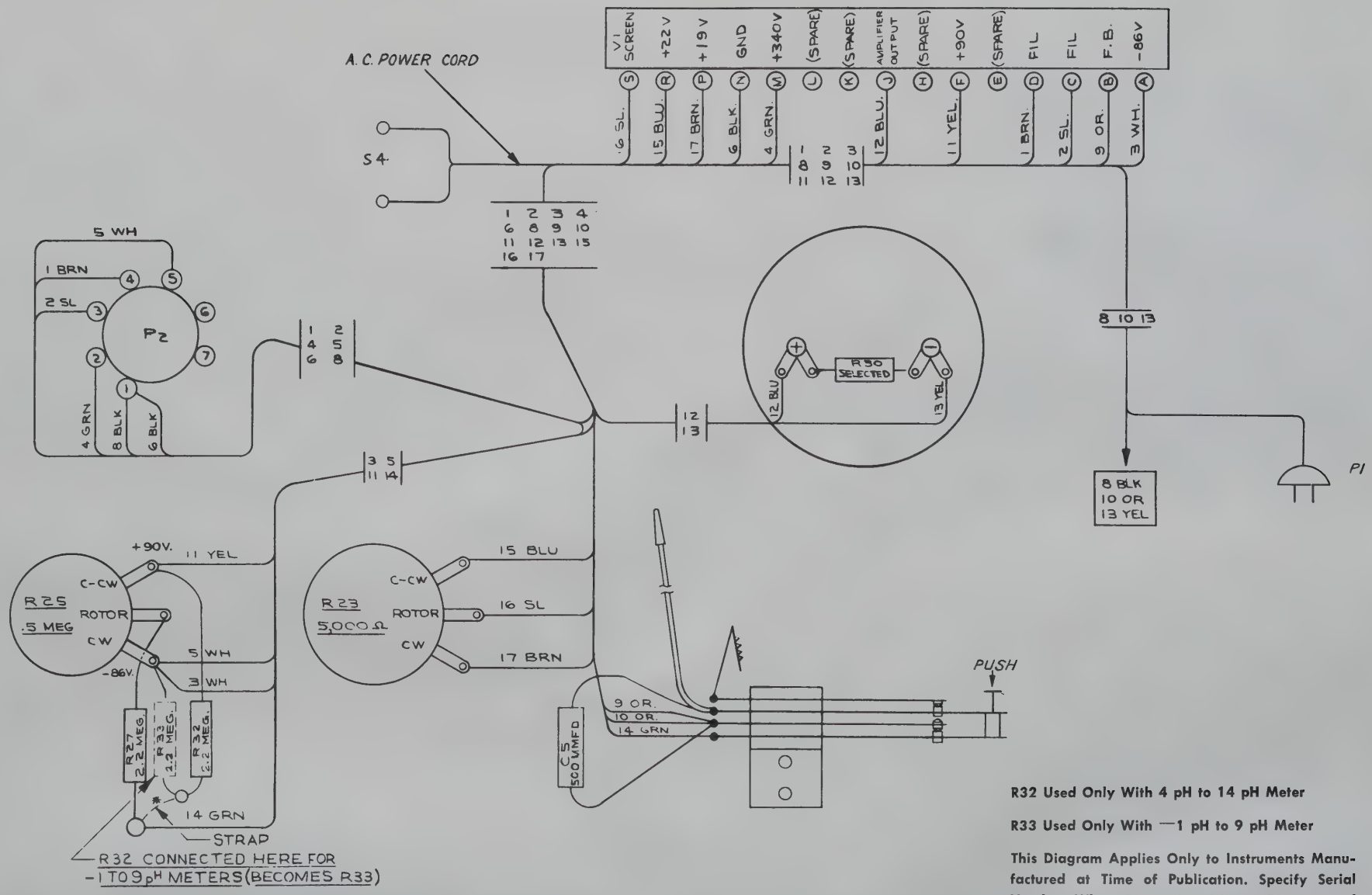
*R32 Used Only With 4 pH to 14 pH Meter

R33 Used Only With —1 pH to 9 pH Meter

Instruments Prior to Serial No. 96347 Did Not Have C7

This Diagram Applies Only to Instruments Manufactured at Time of Publication. Specify Instrument Serial Number When Requesting Wiring Diagrams of Earlier Instruments.

Figure 8. Complete Schematic Wiring Diagram



R32 Used Only With 4 pH to 14 pH Meter

R33 Used Only With —1 pH to 9 pH Meter

This Diagram Applies Only to Instruments Manufactured at Time of Publication. Specify Serial Number When Requesting Wiring Diagrams of Earlier Instruments.

***Add Strap for —1 to 9 pH and 4 to 14 pH Meters**

Figure 9. Pictorial Wiring Diagram

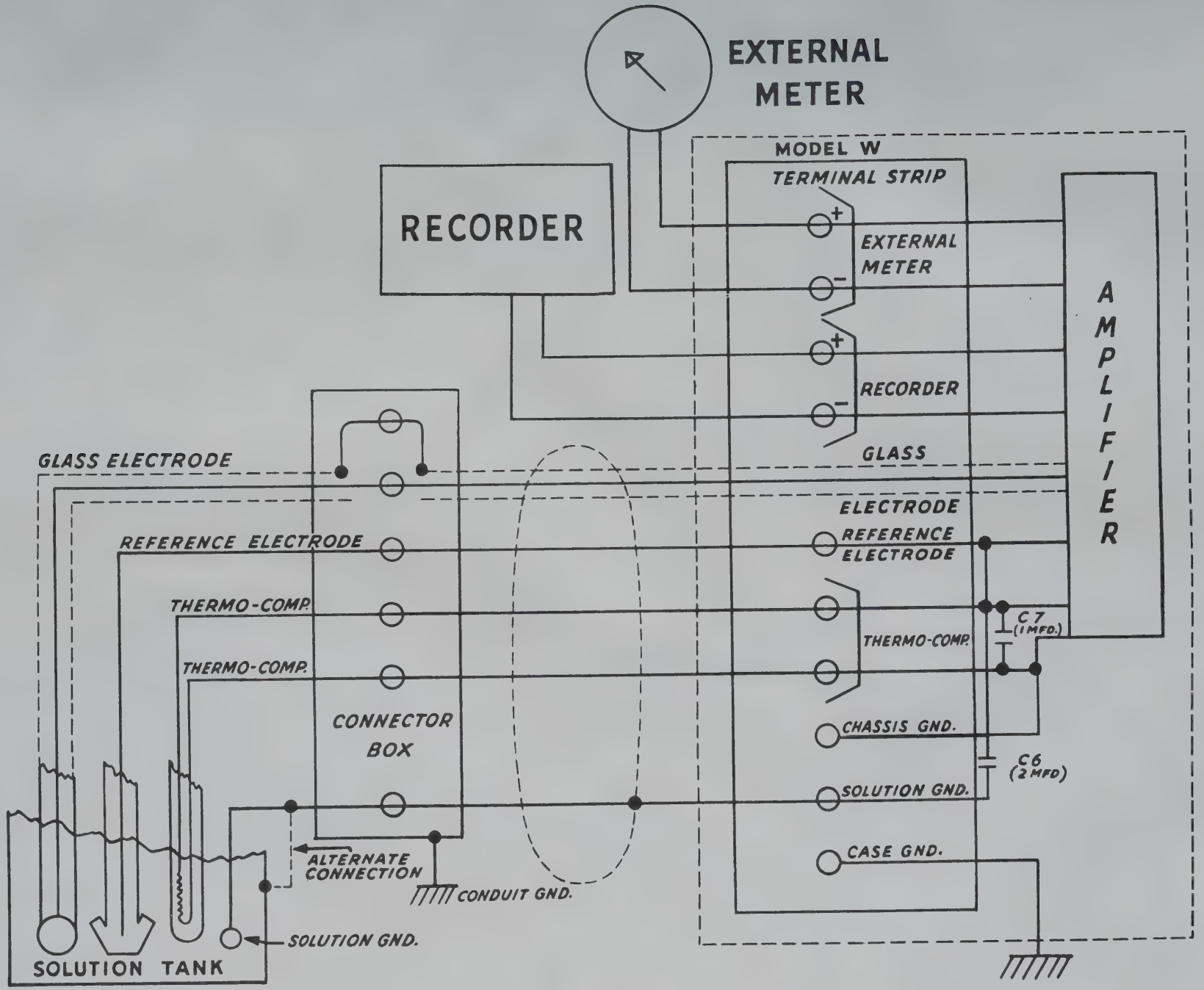


Figure 10. Typical Circuit and Solution Ground Connections

millivolts—is due to manufacturing variations. Wide variations of ambient conditions may also affect the asymmetry potential magnitude. In addition, asymmetry potential may change very slowly as the electrodes age.

The asymmetry potential appears across the thermocompensator, causing the meter of read pH incorrectly. The STANDARDIZE Control supplies an adjustable current which flows through the meter and recorder resistor only; thus the meter can be adjusted to indicate the correct pH regardless of electrode asymmetry potential(s).

The correction current is derived by applying a variable voltage of either polarity across R27. While it would appear from the circuit diagram that part of the correction current would flow through the thermocompensator (feedback resistor), in practice only 1/1,000 of the current will flow through that resistor (because of the feedback amplifier action). This current does not cause any error.

On −1 to 9 or 4 to 14 pH range instruments, an additional current flows through the meter and recorder resistor. This current produces the appropriate shift in the meter and recorder indication for these ranges. The current is derived by applying either +90 volts to R33 or −86 volts to R32.

See Figure 8, the complete schematic wiring diagram of the Model W, or Figure 9, the pictorial wiring diagram.

1. WORKING AMPLIFIER

The input tube V1 is an electrometer tube with grid current less than 2×10^{-12} amperes. It is operated as a pentode and exhibits a voltage gain of about 80. A capacitor and resistor, in series, in the plate circuit of this stage controls the phase-gain relationships of the amplifier loop. The second stage V2 is a voltage amplifier with a gain of about 60.

The voltage divider, R2 and R11, introduces a loss of gain of 3, but enables the signal to emerge at a negative potential with respect to ground so that the output of the amplifier can be operated at ground level for direct feedback connection to the input of the amplifier.

The output stage is a twin triode, V4A and V4B. The output current signal flows between the plate of V4A and ground. V4B is connected in such a manner that the current drawn from the B supply through the ground connection is nearly constant regardless of the output signal level. This arrangement prevents unwanted feedback within the working amplifier itself.

2. POWER SUPPLY

Selenium Rectifiers SR1 and SR2 comprise a voltage doubler circuit to produce 425 volts (at 115-volt ac line voltage) across capacitors C1 and C2 (in series).

This voltage is divided between the resistor string which provides the amplifier voltages and the series regulator tube V6A. The voltage regulator amplifier operates to maintain the string voltage at 176 volts. The input stage of the voltage regulator amplifier, V3, compares the string voltage at the point of its filament supply with the voltage across the voltage reference tube V5.

Any difference in the two voltages (allowing for about two volts of bias between the grid and filament of V3) is amplified by V3 and V6B and the output voltage is applied to the grid of the series regulator tube V6A in such a manner as to maintain a constant voltage between chassis ground and the −86V point. A shunt (Resistor R1) across V6A passes about half of the resistor string current (at nominal line voltage) in order to ease the power requirements of V6A. The power supply is grounded near the midpoint of the resistor string, providing a B+ voltage of +90 volts and a B− voltage of −86 volts.

E. CIRCUIT, SOLUTION GROUNDS

The Model W Industrial pH Meter is designed to measure pH potentials in tanks or vessels which range from "grounded" to "well insulated from ground," and with small a-c and/or d-c potentials existing between the solution and earth ground.

Potentials between the solution and earth grounds will tend to cause current to flow through the reference electrode proper unless the pH meter itself and recorder-controllers or external meters are properly interconnected, shielded, and insulated. Current flow of any type through the reference electrode can develop a false signal. The current through the reference electrode must not exceed 0.1 microamperes.

Figure 10 shows the proper grounding for a typical installation. Capacitors C6 and C7 provide a low impedance path for a-c voltage developed between the reference electrode and solution ground.

Two tests are suggested if grounding trouble is suspected:

1. With the instrument off (disconnect the power plug from the a-c receptacle inside the case), use an ohmmeter with long (but low resistance) leads to check the resistance between the solution or solution tank and

the SOLUTION GROUND terminal in the Model W case. (Resistance of ohmmeter leads should be no greater than one ohm.) If the resistance between the solution and ground is more than five ohms, alter the wiring to reduce the resistance to below five ohms.

2. With the instrument OFF (disconnect the plug inside the case), check for current flow in the reference electrode by inserting a sensitive current meter between the REFERENCE ELECTRODE terminal in the Model W and the reference electrode lead.

If the current is less than 0.1 microamperes, the circuit insulation from ground is satisfactory. If the current is more than 0.1 microamperes, leave the meter connected as indicated and disconnect the following components one at a time:

GLASS ELECTRODE lead
Two THERMO COMP leads
RECORDER leads
EXTERNAL METER leads
Leads to Capacitor C6
Leads to Capacitor C7

If the current persists with all the above leads disconnected, the trouble may be in one of the insulators which isolate the inner chassis from the outer case.

In rare cases the transformer insulation may be at fault. To check this soure, remove the ¼-ampere line fuse, plug the amplifier into the power receptacle, and repeat test 2.

If the trouble is confined to the power transformer, the reference electrode current will be less than 0.1 microampere until the power plug is inserted into its receptacle. Then the current will jump to some higher value. If the transformer is defective in this respect, replace it.

If the trouble is located in any of the thermo-compensator or electrode leads, and connector boxes or electrode switches are used, try to trace the trouble to the exact part of the cable involved.

If the preceding maintenance data proves inadequate to return the Model W to operation, communicate with your Beckman field representative or the factory.

Section III

MODEL WM OPERATION

Figure 11. Model WM Industrial Millivolt Indicator

A. DESCRIPTION

The Model WM Millivolt Indicator is a high impedance d-c voltmeter designed for the measurement of electrochemical potentials. The instrument can be used in conjunction with recorders, controllers, recorder-controllers and/or remote indicating meters. Special electrode switches are available to permit recording with several sets of electrodes through a single instrument. The Model WM is available in one on-scale zero range (−500 to +500 millivolts) and in two off-scale zero ranges (300 to 900 millivolts and 700 to 1400 millivolts).

These instruments feature printed circuits and replaceable plug-in subassemblies interchangeable with the Model W. The Model WM case also is gasketed to exclude moisture and dust, and a bag of desiccant is supplied for clipping to the inside of the case (see Figure 5).

B. SPECIFICATIONS

1. ***Input Power:*** 50/60 cycle, 95-132 volts, 25 watts.

2. ***Ambient Temperature:*** −20° C to 50° C. See Bulletin 86 or Bulletin 342 for ambient temperature of electrodes.

3. ***Ambient Humidity:*** 100%.

4. ***Indicator:*** 204 (102-0-102) microamperes, 3½ in. scale.

5. ***Warm-Up Time:*** 30 minutes.

6. ***Maximum Drift:*** 5 mv/day. Initial drift rate of 3 to 5 mv/hour reduces to 5 mv/day after 48 hours operation.

7. ***Accuracy:*** Recorder output—0.2% of full-scale. Panel meter 1% of full-scale. (Reproducibility of panel meter is 0.2% of full-scale.)

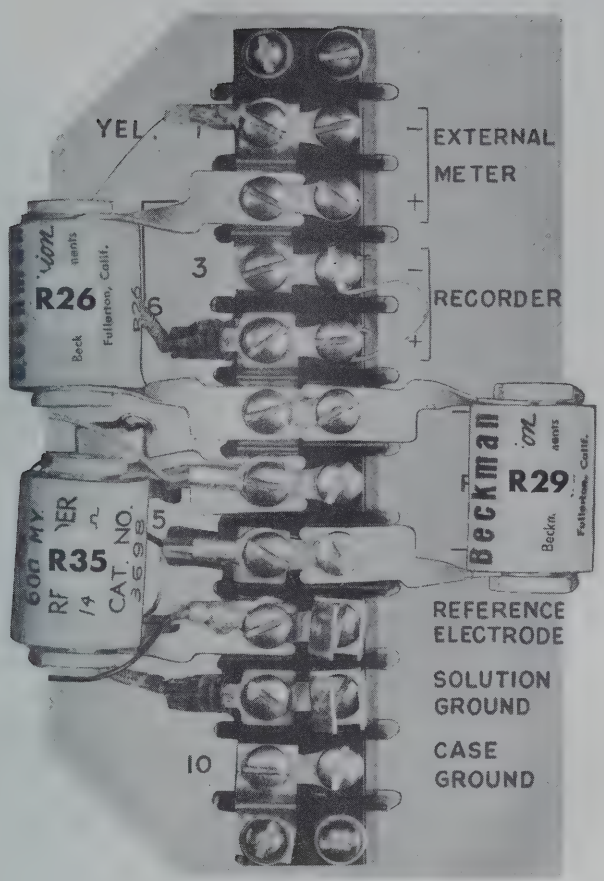


Figure 12. Model WM Terminal Connections

8. ***Response:*** Amplifier response 2.0 seconds (may be further limited by electrode response).

9. ***Output Signals*** (for full-span):

a. Recorder Controller
10 to 500 millivolts (potentiometric type)
204 microamperes (current type)

Recorders should have mid-scale zero or provision for setting zero to mid-scale.

b. External Meter
102-0-102 microamperes

10. ***Input Detector Elements:***

a. Standard Beckman Metallic Electrode

b. Standard Beckman Reference Electrode

NOTE: *Consult a Beckman Sales Engineer for advice in selection of electrodes for specific applications. Beckman electrodes are described and illustrated in Bulletins 86 and 342.*

C. RECORDER REQUIREMENTS

Model WM recorder requirements are same as those for the Model W. See Section I, C, and Appendix I.

D. INSTALLATION

See Model W mounting instructions in Section I, D.

E. TERMINAL CONNECTIONS

Model WM terminal connections are illustrated in Figure 12 and described in Section I, D (similar to those for Model W). Note that the terminal numbers will differ in some instances and that the "glass electrode" connection (Model W) is called the "measuring electrode" connection on the Model WM. No thermo-compensator connections are required for the Model WM.

NOTE: *Leads to external indicating meters, recorders, or recorder-controllers must be well-insulated. Leads longer than 10 feet must be shielded, and the shield must be connected to terminal 10 on the Model WM terminal strip. The shield must be insulated to prevent contact with earth ground or other conductors. A two-conductor shielded cable (Beckman Part 1203) may be obtained from the factory. Specify length required.*

F. OPERATING CONTROLS

1. ON-SCALE ZERO RANGE

a. ZERO CHECK Push Button

Depressing the ZERO CHECK Push Button disconnects the electrodes from the amplifier and shorts the input terminals. This control is used (in conjunction with the ZERO Control) to zero the amplifier.

b. ZERO LOCK Push Button

This control locks the ZERO CHECK Push Button down, disconnecting the electrodes from the amplifier while the electrodes are removed from solution. This prevents polarization (important with some types of electrodes). To lock the ZERO CHECK Push Button down, press both push buttons simultaneously, and release the ZERO CHECK Push Button first. To unlock, press and release the ZERO CHECK Push Button.

c. ZERO Control

This control is used to adjust the input of the amplifier to ground potential.

NOTE: *If the ZERO Control does not have sufficient range for proper operation, it will be necessary to adjust the Coarse Zero Control (R24)—an adjustable wire-wound resistor located on the Printed Circuit Board. See Section II, A, 1, a.*

d. Meter Zeroing Control

Adjust the mechanical zero of the meter if the meter needle does not balance at mid-scale when the a-c power is disconnected. To gain access to this control screw, remove the snapbutton plug from the hole in the panel just below the meter face.

2. OFF-SCALE ZERO RANGES

a. SET A Control

This is an amplifier bias control.

b. SET B Control

This control is used to adjust a second bias voltage inserted in series with the input signal, in order to provide a zero signal off-set.

c. SET A Push Button

When this push button is depressed, the input electrode is disconnected, the amplifier input is connected to the feedback resistor, and a lead is disconnected from the SET B Control to make the control inoperative.

d. SET B Push Button

This push button also is used to disconnect the input electrode and to connect the amplifier input to the feedback resistor; the SET B Control remains operative, however.

e. Meter Zeroing Control

The mechanical zeroing adjustment is the same as for the on-scale zero range instrument (−500 to +500 millivolts) previously described.

G. STEPWISE OPERATION

1. ON-SCALE ZERO RANGE

a. Check mechanical zero of the indicating meter.

b. Connect the power plug to the a-c receptacle on the rear panel and allow 30 minutes for "warm-up."

c. Clean the reference and measuring electrodes and immerse these units in the test solution.

d. Lock down the ZERO CHECK Push Button and rotate the ZERO Control to balance the meter needle to zero millivolts.

e. Unlock the ZERO CHECK Push Button; the meter will automatically indicate the potential (in millivolts) developed by the electrodes in solution.

2. OFF-SCALE ZERO RANGES

a. Check the mechanical zero of the indicating meter; the needle should rest at mid-scale.

b. Connect the power plug to the a-c receptable on the rear panel and allow 30 minutes for "warm-up."

c. Clean the electrodes and immerse these units in the test solution.

d. Hold down the SET A Push Button and rotate the SET A Control to balance the meter needle at Point A on the scale.

e. Hold down the SET B Push Button and rotate the SET B Control to balance the meter needle at Point B on the scale.

f. Release SET B Push Button; the meter will automatically indicate the potential (in millivolts) developed by the electrodes in solution.

Section IV

MODEL WM MAINTENANCE

Symptoms and remedies, procedures for removing and replacing amplifier plug-in units, trouble-shooting tests, and circuit and solution ground tests are basically similar to those described for the Model W in Section II, A, Section II, B, Section II, C, and Section II, E, respectively.

A. CIRCUIT OPERATION

Figure 13 is the basic circuit diagram for the on-scale zero range (−500 to +500 millivolts), showing the operating controls and their relationship to the circuit; Figure 14 is the pictorial wiring diagram. The amplifier is a voltmeter employing negative voltage feed-back to stabilize the gain and to degenerate the input impedance. The zeroing operation consists of connecting the input terminals of the amplifier to the feedback resistor and setting the meter or recorder to zero. (The measuring electrode lead is disconnected during this operation to prevent polarization of the electrodes.)

For the instruments which have an off-scale zero input voltage (300 to 900 or 700 to 1400 millivolt ranges) additional circuitry is necessary to provide for the input biasing voltage; Figure 15 shows the basic circuit; Figure 16 is the pictorial wiring diagram. By comparing Figure 15 with Figure 13, it can be seen that Resistor R35 has been added in series with the input signal voltage.

A current flows through R35 to produce the bias voltage. The current is obtained through resistors R36 and R37 (Figure 15) from a −86 volt supply. This current is adjustable for calibration purposes. Current through resistor R38 affects only the meter reading and not the bias voltage.

This current source, though not necessary in the strict sense, is used to reduce the errors originating in meter non-linearity to the smallest practical value. If the instrument is operated using a recorder as the output indicator, the linearity of the recorder readings will be that of the recorder itself.

In operation, the SET A Push Button is depressed to connect the amplifier input to the feedback resistor and disconnect R36 from the circuit so that no current flows through resistor R35; therefore, no input bias voltage is developed across R35. Current still flows through resistor R38, but this current flows only through R26 and the meter and does not produce an appreciable voltage drop across the feedback resistor R29. Approximately 1/1,000 of the current supplied by R38—about

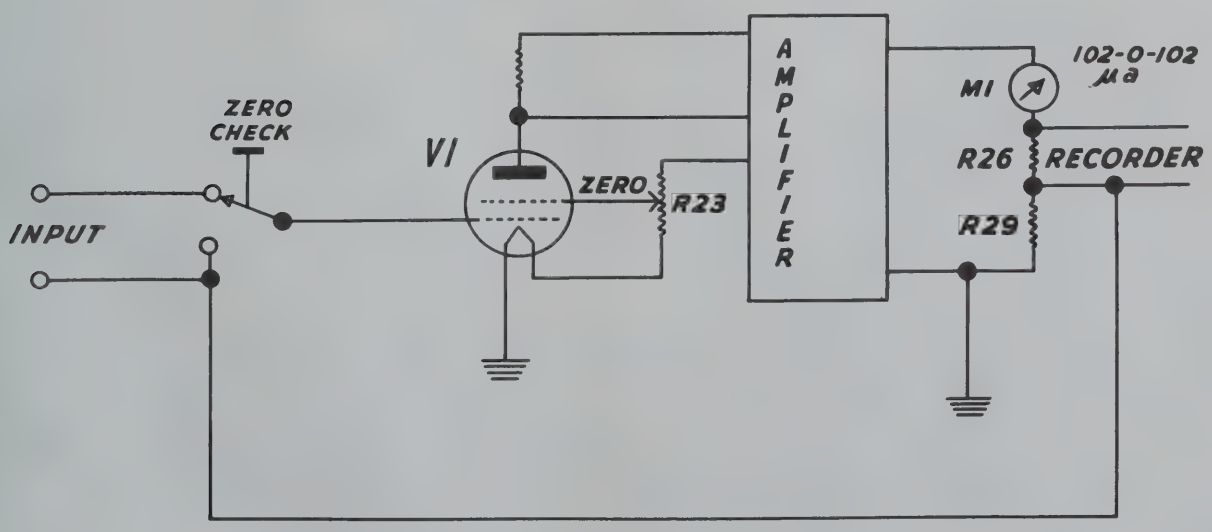


Figure 13. Basic Circuit Diagram, —500 to +500 MV Range

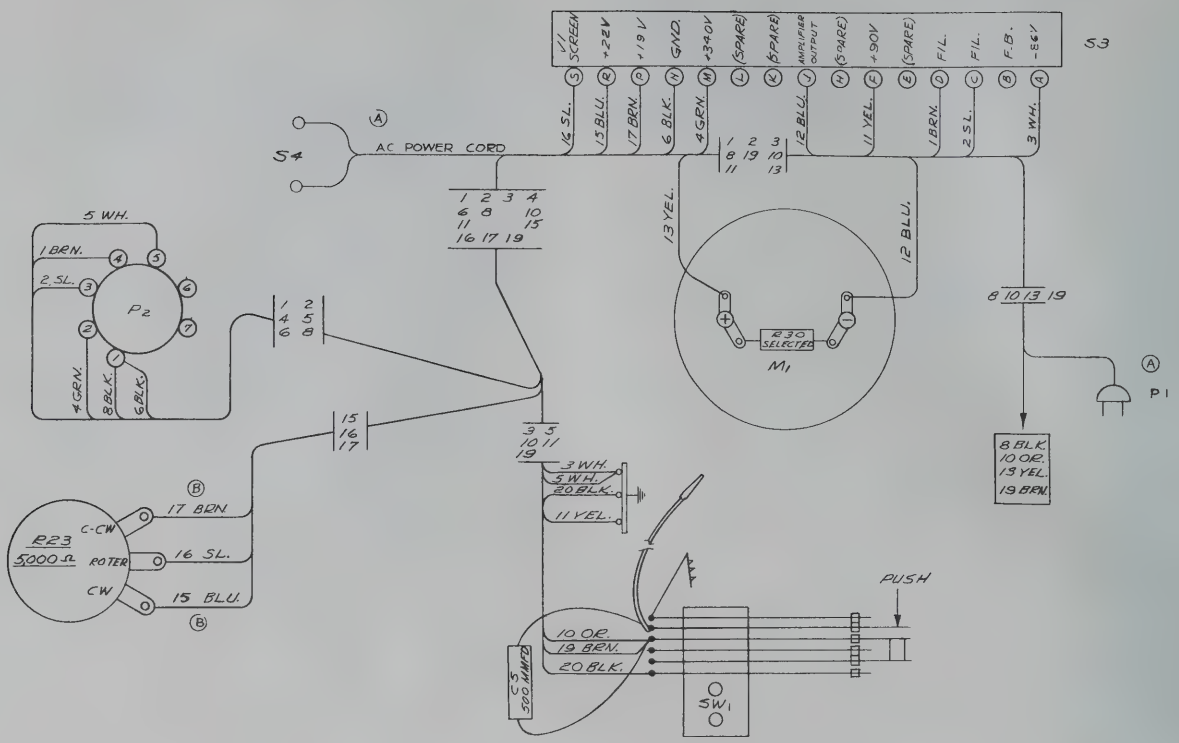


Figure 14. Pictorial Wiring Diagram, —500 to +500 MV Range

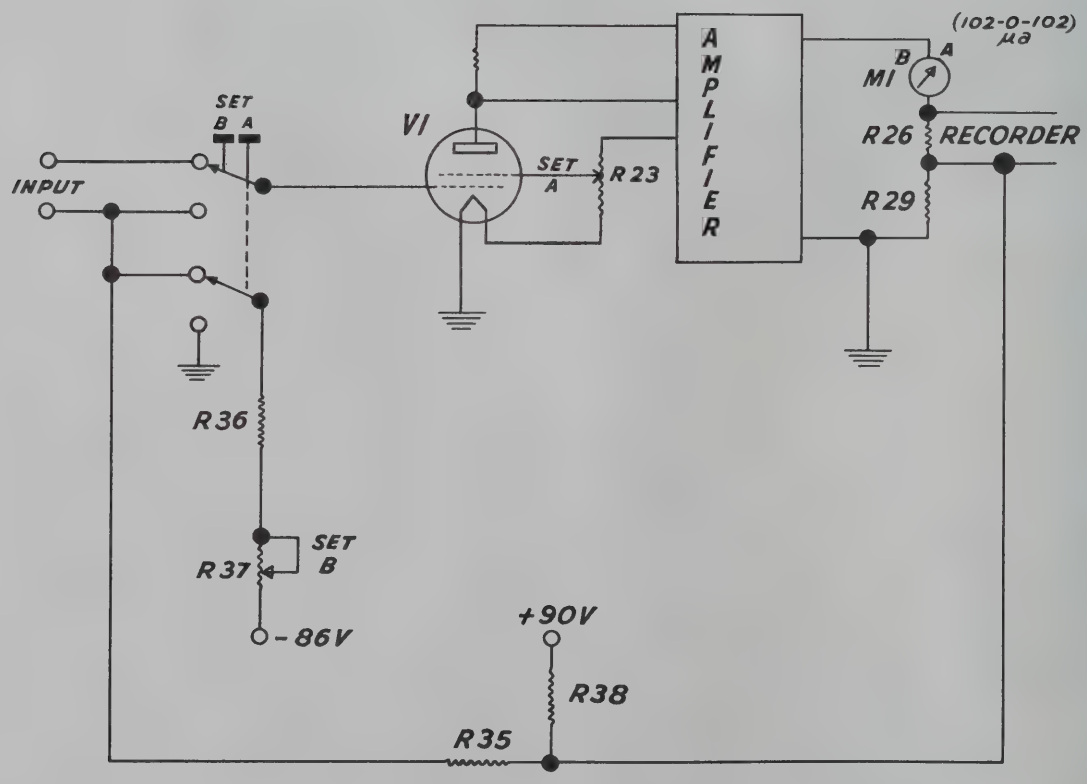


Figure 15. Basic Circuit Diagram, 300 to 900 and 700 to 1400 MV Ranges

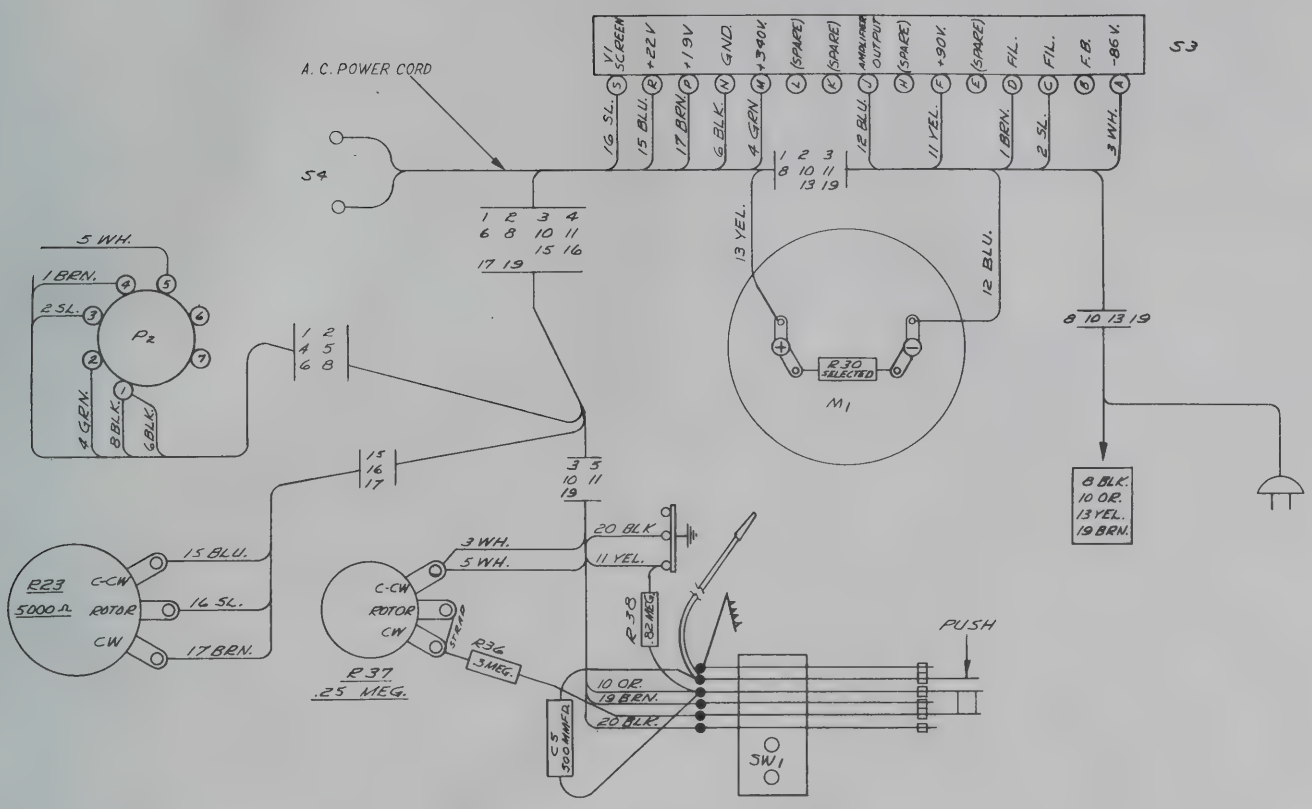


Figure 16. Pictorial Wiring Diagram, 300 to 900 and 700 to 1400 MV Ranges

0.1 microampere—will flow through R29. The current supplied to the meter by R38 is sufficient to drive the meter about half-scale (from mid-scale zero to full-scale).

With the SET A Push Button depressed, the SET A Control is adjusted to bring the meter to exactly full-scale (Point A on meter scale). The SET A Control is the amplifier bias control. Because the current supplied by R38 may not be exactly half-scale current, and because of meter non-linearity, the input grid may not be at ground potential; it will be within 50 millivolts of ground, however.

With the SET A operation completed, the SET B Push Button is depressed. Current is supplied to the bias resistor R35, but the input bias voltage developed across R35 is not yet connected into the amplifier input circuit. As with the current supplied by resistor R38, this current flows only through the meter and recorder resistor R26.

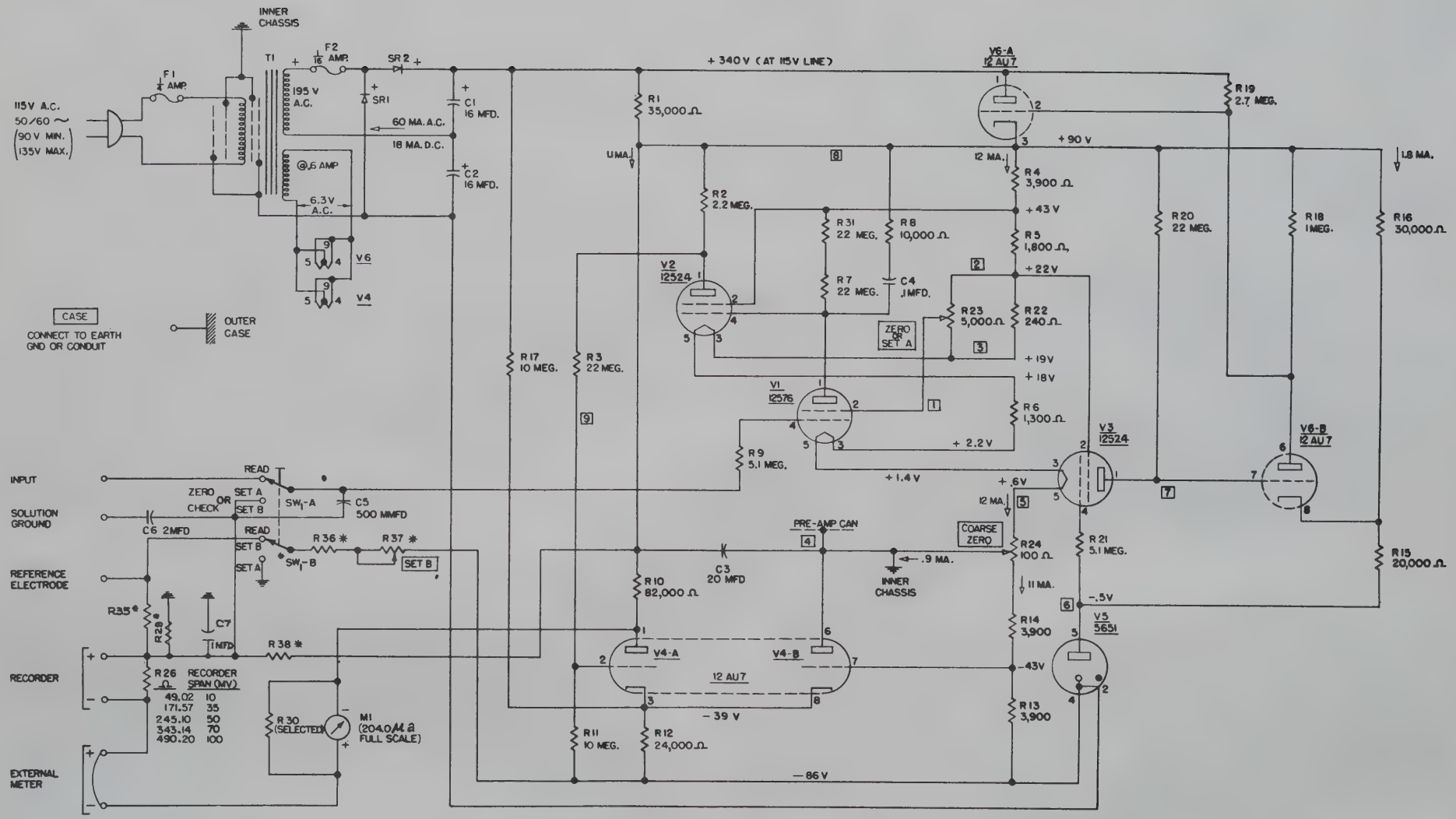
The values of resistors R35 and R29 are so selected that when the meter current has changed by 204 microamperes (full-scale sensitivity), the desired input bias voltage is developed across R35.

With the SET B Push Button depressed, the SET B Control is adjusted to bring the meter needle to Point B (left end of scale). When the SET B Push Button is released, the input bias voltage developed across R35 is connected in series with the amplifier input.

The instrument is now ready for signal measurement. If the signal is less than the voltage set across R35, the meter will indicate off-scale to the left. The meter will indicate on-scale values only when the input signal is greater than the bias voltage across R35.

Figure 17 is the complete schematic wiring diagram for all three ranges of the Model WM.

The Model WM Working Amplifier and the Power Supply function in the same manner as the Model W Working Amplifier and the Model W Power Supply. See Section II, D, 1, and Section II, D, 2, respectively.



* RESISTANCE VALUES DEPEND UPON MILLIVOLT RANGES AS FOLLOWS:

RANGE (MV)	R 29(Ω)	R 35(Ω)	R 36(Ω)	R 37(Ω)	R 38(Ω)
- 500 TO +500	4902.0	SHORTED	OMITTED	OMITTED	OMITTED
300 TO 900	2941.2	1470.6	300,000	250,000	820,000
700 TO 1400	3431.4	3431.4	300,000	250,000	820,000

SWITCH SW_1-B IS OMITTED ON -500 MV TO +500 MV RANGE

☐ REFERS TO PIN CONNECTION OF PRE-AMPLIFIER UNIT

Figure 17. Complete Schematic Wiring Diagram, Three Model WM Ranges

Appendix I

RECORDER MODIFICATION

The following information is presented to help the operator modify the Model W Industrial pH Meter for almost any pH recording requirement. These procedures apply only to potentiometric type recorders and to the Model W. (Consult a Beckman Sales Engineer for modification data for the Model WM Industrial Millivolt Indicator.)

If additional recorder modification data is required, consult the recorder manufacturer.

A. RECORDER RESISTOR

The Model W recorder output voltage is determined by the recorder resistor (R26). By proper choice of the value of R26, the recorder pH scale can be made to agree with the Model W panel meter, or it can be expanded or compressed as desired.

The exact value of R26 can be computed as follows:

$$\text{Resistance of R26 in ohms} = \frac{\text{Recorder Span in millivolts}}{\text{Desired Recorder Span in pH Units} \times 0.0204}$$

For example, if it is desired to spread 3 pH units over the full scale of 100 mv span recorder, the value of R26 would be computed as follows:

$$\text{Resistance of R26 in ohms} = \frac{100}{3 \times 0.0204} = 1634 \text{ ohms}$$

B. RECORDER ZERO SHIFTING

The Model W has zero output at mid-scale. If the recorder to be used with the Model W does not have a mid-scale zero or any provision for adjusting its zero to mid-scale, a simple bias circuit can be installed to shift the zero. An "A" battery and a resistor network should be used to furnish the voltage.

NOTE: *Insert the bias voltage between one recorder input terminal and the corresponding Model W recorder output terminal.*

The exact zero shifting voltage required for any Model W recorder installation can be computed as follows:

$$\text{Auxiliary Zero Shifting Voltage in mv} = \text{Recorder Span in mv} \times \frac{\text{Model W Meter Reading in pH Units for 0-mv Output} - \text{Desired Recorder Reading in pH at Original 0-mv Input Point}}{\text{Desired Recorder Span in pH Units}}$$

EXAMPLE 1.

Assume that the available Model W and 100-mv span recorder both have 2 to 12 pH ranges, but the recorder has a left-scale zero input point which cannot be shifted internally. The auxiliary zero shifting voltage required in this instance would be computed as follows:

$$\text{Auxiliary Zero Shifting Voltage} = 100 \times \frac{(7\text{-}2)}{(10)} = 100 \times \frac{(5)}{(10)} = 50 \text{ mv}$$

EXAMPLE 2.

Assume that the Model W has a 2 to 12 pH range and that the recorder has a 1 to 4 pH range. The recorder has a left-scale zero input point which cannot be shifted internally. The total auxiliary zero shifting voltage required in this instance would be computed as follows:

$$\text{Auxiliary Zero Shifting Voltage in mv} = 100 \times \frac{(7\text{-}1)}{3} = 100 \times \frac{6}{3} = 200 \text{ mv}$$

Obviously, the required external zero shifting voltage can be similarly computed for any other Model W recorder installation, regardless of where the original zero input point is located on the recorder scale.

MODEL W PARTS LIST

SYMBOL	DESCRIPTION	BECKMAN PART
	Printed Circuit Board Assembly	7437
	Printed Circuit Board	7436
R1	35,000 ohms, 10 watt, Ward Leonard	7456
R10	82,000 ohms, ½ watt, 5%, Ohmite	15072
R11, R17	10 meg, ½ watt, 5%, Ohmite	8154
R12	24,000 ohms, 1 watt, 5%, Ohmite	6270-556-9
R13, R14	3,900 ohms, 2 watt, 2%, Tomore S2W	7463
R15	20,000 ohms, ½ watt, 5%, Ohmite	15057
R16	30,000 ohms, ½ watt, 5%, Ohmite	9098
R18	1 meg, ½ watt, 5%, Ohmite	3180-15
R19	2.7 meg, ½ watt, 5%, Ohmite	8107
R24	100 ohms, adj, 10 watt, Mallory 1AV100	7455
C3	20 mfd, 350 volt, Sprague TVA 1608	7451
	Socket, Tube 7-pin, Methode P-153, for V5	7438
	Socket, Tube 9-pin, for V4 and V6	7440
	Socket, Tube 9-pin, for Preamplifier	7435
V4, V6	12AU7 Tube, RCA	12015
V5	5651 Tube, RCA	173
	Power Supply Assembly	4282
T1	Transformer, Power	7448
SR1, SR2	Rectifier, Selenium	6775
C1, C2	Capacitor, 16 mfd, 450 volt, Mallory TC74	7449
	Fuse Holder, Buss HKP	7268
F1	Fuse, .25 amp, Slo Blo Littelfuse 313-250	15101
F2	Fuse, 1/16 amp, Slo Blo Littelfuse 313-062	442
	Chassis Assembly, Riveted	7444
	Preamplifier Assembly	7460
	Panel Mounted Components	
R23	Potentiometer, 5,000 ohms ± 10%, 4 watt, W.W. Linear Taper, 15/16 Round Shaft FMS, 3/8 Bushing, Mallory Type M.	6996
R25	Potentiometer, .5 meg, 2 watt, Allen Bradley JU5041, Shaft SD3056	15138
R27	2.2 meg, ½ watt, 5%, Ohmite	12029
C5	.0005 mfd, 600 volt, 20%, Fast 30FS3	9029
	Snapbutton Plug	4279
	Miscellaneous Parts	
	Key	7388
	Desiccant, 2 oz bag, Protek-Sorb, Davidson Chemical Company	3694
	Input Circuit Cover	7417
	Chassis Cover	7422
	Terminal Strip, Howard B. Jones 10-141	2603
	Terminal Plate	7494
	Desiccant Clamp	7499
	Short Circuit Strap, Short (for terminal strip)	7487
	Short Circuit Strap, Long (for terminal strip)	7476
	Allen Wrench	6201-22

	Conduit Sealer, 5 oz Tube, Minn. Mining & Mfg. Co., Formula EC-373	7096
	Thermo-Compensator Assembly	7483
	Recorder Resistor Assembly (10 mv Recorder)	6956
	Recorder Resistor Assembly (35 mv Recorder)	7394
	Recorder Resistor Assembly (50 mv Recorder)	7395
	Recorder Resistor Assembly (70 mv Recorder)	7396
	Recorder Resistor Assembly (100 mv Recorder)	7097
	Buffer Solution, 7 pH	3681
C6, C7	2 + 1 mfd, 600 volt DC, Industrial Cond. Corp., Type HA.	6774
R32	2.2 meg, ½ watt, 5%, Ohmite (4 to 14 pH Range)	12029
R33	1.5 meg, ½ watt, 5%, Ohmite (−1 to 9 pH Range)	13193
M1	Meter Assembly (2 to 12 pH)	3696
	Meter Assembly (−1 to 9 pH)	3697
	Meter Assembly (4 to 14 pH)	3813

MODEL WM PARTS LIST

SYMBOL	DESCRIPTION	BECKMAN PART
M1	Meter Assembly (−500 to +500 mv)	6799
R29	Resistor Assembly (−500 to +500 mv), 4,902 ohms	6981
M1	Meter Assembly (300 to 900 mv)	6798
R29	Resistor Assembly (300 to 900 mv), 2,941.2 ohms	6975
R35	Resistor Assembly (300 to 900 mv), 1,470.6 ohms	3698
R36	Resistor (300 to 900 mv), 30,000 ohms, ½ watt, 5%, Ohmite	9098
R38	Resistor (300 to 900 mv), 82,000 ohms, ½ watt, 5%, Ohmite	15072
M1	Meter Assembly (700 to 1400 mv)	6787
R29	Resistor Assembly (700 to 1400 mv), 3,431.4 ohms	6976
R35	Resistor Assembly (700 to 1400 mv), 3,431.4 ohms	3699
	Terminal Plate	6974
C6	2 mfd, 600 volt DC, Tobe Oilmite OM-602	15121

Other Model WM Parts same as Model W Parts.

NOTES

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